(19) Japan Patent Office (JP)

(12) Publication of Unexamined Patent Application (A)

(11) Japanese Patent Laid-Open Number: Hei 9-329744

(43) Laid-Open Date: Hei9-12-22 (December 22, 1997)

(51) Int.Cl.6 Identification Code Office Reference Number FI

G 02 B 15/10

15/02

Request for examination: No request to be done

Number of Invention: 5 FD (7 pages in total)

(54) Title of the Invention: Imaging size conversion optical system

(21) Application Number: Hei 8-168312

(22) Filed: Hei 8-6-7 (June 7, 1996)

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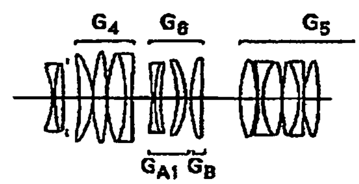
[Title of the Invention]

Imaging size conversion optical system

[Abstract]

[Problem] To provide an imaging size conversion optical system that does not cause the change of the field angle even when a photography lens is attached to a camera having a different size of imaging device (in particular, camera having a small imaging size); that can convert a plurality of imaging sizes in addition to the normal imaging size; and that is small, light-weight, and bright.



[Means for Solving the Problem] The present invention has: the photography lenses G_1 to G_5 and the detachable lens group G_6 that can be attached to the light paths of the photography lenses G_1 to G_5, the detachable lens group G_6 has therein the interchangeable lens group G_A that can be exchanged, thereby providing the status in which the detachable lens group G_6 is removed, the status in which the detachable lens group G_6 is attached, and the status in which the interchangeable lens group G_A is exchanged. The present invention is characterized in that the total of three types or more imaging sizes can be satisfied and the condition of $0.5<\beta<0.9$ is satisfied when the conversion magnification of the detachable lens group G6 is represented by β.

[What is claimed is:]

[Claim 1] An imaging size conversion optical system, comprising:

a photography lens; and

a detachable lens group that can be attached to the light path of the photography lens,

wherein:

the detachable lens group has therein an interchangeable lens group that can be exchanged, thereby providing a status in which the detachable lens group is removed; a status in which the detachable lens group is attached, and a status in which the interchangeable lens group is exchanged so that the total of three types or more imaging sizes can be converted and the condition of $0.5<\beta<0.9$ is satisfied when the conversion magnification of the detachable lens group is represented by β.

[Claim 2] An imaging size conversion optical system according to Claim 1, wherein:

the detachable lens group is composed of, from an object side, the lens group G_A having negative refracting power and the lens group G_B having positive refracting power, and

when the conversion magnification is changed, a part or the entirety of the lens group G_B having positive refracting power is moved in an optical axis direction and, when the conversion magnification β of the detachable lens group is minimum, a part or the entirety of the lens group G_B having positive refracting power is closest to the image in terms of their positions.

[Claim 3] An imaging size conversion optical system according to Claim 1 or 2, wherein:

the detachable lens group has at least one set of composite lenses; and

the interchangeable lens group that is exchanged in order to change the conversion magnification of the detachable lens group has at least a

single positive lens or a composite positive lens.

[Claim 4] An imaging size conversion optical system according to Claim 1 or 2, wherein:

the detachable lens group has at least one set of composite lens; and

the interchangeable lens group that is exchanged in order to change the conversion magnification of the detachable lens group has at least a single negative lens or a composite negative lens and, the single negative lens or the composite negative lens has the maximum negative refracting power among those in the detachable lens group.

[Claim 5] An imaging size conversion optical system according to Claim 1, 2, 3, or 4 wherein an object side face of the single negative lens or the composite negative lens in the detachable lens group that is provided at a position closest to the object has a convex shape toward the image side.

[Detailed Description of the Invention]

[0001]

[Technical Field]

The present invention generally relates to the field of imaging optics (e.g., camcorder, silver salt film camera).

[0002]

[Problem to be Solved by the Invention]

Recently, a solid state imaging device used for a camcorder or the like has a tendency where the size of the device has been reduced year by year due to the reduction of the camera size and due to the increase of the yield (throughput) of solid state imaging devices. For example, in the case of a camcorder for consumer market not requiring a very high image quality, solid state imaging devices having a size of 1/3 inches have been mainly used and some of the recently-developed solid state imaging devices have the size of 1/4 inches or 1/5 inches. In the case of broadcasting and

professional-use camcorders requiring a high image quality, solid state imaging devices having a size of 2/3 inches and 1/2 inches are still mainly used. In the case of a hi-vision camcorder requiring the highest image quality, solid state imaging devices having a size of 1 inch are still mainly used. In other words, as shown above, there are cameras including various imaging devices depending on various applications that involve the existence of corresponding exclusive photography lenses having a suitable size at present.

[0003]

When a photography lens for a small imaging device is attached to a camcorder including a large imaging device, an imaging region larger than a photography region is shifted toward the wide angle side and the vignetting of ray is caused. Thus, in order to solve this, conversion magnification must be increased for an imaging. However, the tendency where imaging devices have a reduced size year by year reduces the necessity to cope with such a situation. On the other hand, when a photography lens for a large imaging device is attached to a camcorder including a small imaging device, an imaging region larger than a photography region prevents the vignetting of ray but causes the photography region to be shifted to the telescopic side. Thus, in order to solve this, the conversion magnification must be reduced for the imaging. In other words, in order to cope with imaging devices having reduced sizes and to increase the operation efficiency of camera lenses, a photography lens having a wide imaging region is also used for a camera including a small imaging device so that the lens can be commonly used. However, this causes the shortage of the wide angle side.

[0004]

In order to solve this, a method is disclosed in Japanese Laid-Open Publication No. 63-276012 in which a re-imaging optical system is inserted between a photography lens and a camera. However, this method requires an imaging lens for providing a conjugated relation between an imaging face of a photography lens and an imaging device face as well as a prism system

for preventing the inversion of the image, thus causing the optical system to be very big and heavy. This method also limits the size of a prism for preventing the inversion of an image, thus causing a defect in which the optical system cannot be bright.

[0005]

Japanese Laid-Open Publication No. 7-199067 also discloses an imaging size conversion optical system having another method. However, this technique can convert only one type of imaging size in addition to the normal imaging size and thus is insufficient to cope with a current diversified camera situation. Thus, the present invention has an objective of providing an imaging size conversion optical system that solves the problems as described above; that does not cause the change of the field angle even when a photography lens is attached to a camera having a different size of imaging device (in particular, camera having a small imaging size); that can convert a plurality of imaging sizes in addition to the normal imaging size; and that is small, lightweight and bright.

[0006]

[Means for Solving the Problem]

In order to solve the above problem, the present invention provides: an imaging size conversion optical system, comprising: a photography lens; and a detachable lens group that can be attached to the light path of the photography lens, wherein: the detachable lens group has therein a interchangeable lens group that can be exchanged, thereby providing a status in which the detachable lens group is removed; a status in which the detachable lens group is attached, and a status in which the interchangeable lens group is exchanged so that the total of three types or more imaging sizes can be converted and the condition of

$$0.5<\beta<0.9$$

is satisfied when the conversion magnification of the detachable lens group is represented by β.

[0007]

When the conversion magnification β of the detachable lens group exceeds the lower limit value of the above conditional equation, the power of each lens group in the detachable lens group must be stronger, causing difficulty in the aberration correction. On the contrary, when β exceeds the upper limit value of the above conditional equation, each lens group in the detachable lens group has a reduced power but the conversion magnification is not sufficiently reduced, thus causing no significant difference between when the detachable lens group is attached and when the detachable lens group is removed, which is not the use of a system providing an advantageous effect.

[0008]

In the present invention, it is preferable that: the detachable lens group is composed of, from an object side, the lens group G_A having negative refracting power and the lens group G_B having positive refracting power, and when the conversion magnification is changed, a part or the entirety of the lens group G_B having positive refracting power is moved in an optical axis direction and, when the conversion magnification β of the detachable lens group is minimum, a part or the entirety of the lens group G_B having positive refracting power is closest to the image in terms of their positions.

[0009]

Generally, when an almost afocal optical system having two groups having negative and positive refracting powers is provided in the light path of a photography lens, an image circle that would have been originally generated by the photography lens can be reduced. Thus, when a photography lens for a large imaging device is attached to a camera including a small imaging device, an image swerving out of the imaging region of the imaging device is reduced and is provided in the photography region of the imaging device. Due to this reason, the detachable lens group of the present invention is also preferably provided by an almost afocal optical system. When the detachable lens group is provided by an almost afocal system, a field angle obtained when the detachable lens group is

removed with a large imaging size and a field angle when the detachable lens group is attached with a small imaging size are almost the same. Thus, when the detachable lens group is removed with a small imaging size, shift to a telescopic side is caused. Thus, when only an imaging device having a small imaging size is used, the use with two zoom regions can be provided.

[0010]

In this way, attachment and detachment of the detachable lens group can change the image size of a photography lens and can move the detachable lens group in an optical axis direction to compensate the movement of a focal point at focusing, which also provides further continuous zooming. Furthermore, the entire detachable lens group is not exchanged but the interchangeable lens in the detachable lens group is exchanged so that an uninterchangeable lens in the detachable lens group is moved according to the need. As a result, the third or other imaging device can be handled, thus providing the effective use of the photography lens and providing the entire lens system with a smaller size and lighter weight.

[0011]

In the present invention, it is also preferable that the detachable lens group has at least one set of composite lenses; and the interchangeable lens group has at least a single positive lens or a composite positive lens. In the present invention, it is also preferable that the detachable lens group has at least one composite lens; and the interchangeable lens group has at least a single negative lens or a composite negative lens and, the single negative lens or the composite negative lens has the maximum negative refracting power among those in the detachable lens group. In the present invention, it is also preferable that an object side face of the single negative lens or the composite negative lens in the detachable lens group that is provided at a position closest to the object has a convex shape toward the image side.

[0012]

[Embodiments of the Invention]

Hereinafter, embodiments of the present invention will be described. Figure 1 shows a photography lens of one embodiment of the present invention. Figure 2 shows the detachable lens group G_6 of the same embodiment. The photography lenses are composed of the five groups in which the first lens group G_1, the fourth lens group G_4, and the fifth lens group G_5 are fixed while zooming is performed and the second lens group G_2 and the third lens group G_3 are moved while zooming is performed. As shown in Figure 2, the detachable lens group G_6 is attached between the fourth lens group G_4 and the fifth lens group G_5 of the photography lenses. The detachable lens group G_6 is composed of, from an object side, the lens group G_{A1} having negative refracting power and the lens group G_B having positive refracting power to provide almost an afocal system. Among them, the lens group G_{A1} having negative refracting power is the first interchangeable lens group while the lens group G_B having positive refracting power is an uninterchangeable lens group. Figure 3 shows the first interchangeable lens group G_{A1} of the detachable lens group G_6 exchanged with the second interchangeable lens group G_{A2}. In this embodiment, the uninterchangeable lens group G_B of the detachable lens group G_6 is moved in the direction of an optical axis.

[0013]

Table 1 shown below shows the specification of the photography lens of the first embodiment. In [Entire specification], f represents the focal distance of the entire system and Y represents an image height. In [Lens specification], the first column No. represents the No. of each lens face from the object side; the second column r represents the radius of curvature of each lens face; the third column d represents the distance between lens faces; the fourth column v represents Abbe number with regards to the d line of each lens (λ=587.6nm); and the fifth column n_d represents the refractive index to d line of each lens. Furthermore, parallel flat plates as a color separation prism, various filter or the like are disposed between the

final face and the image face of the photography lens, and these faces including them are subjected to aberration correction. Thus, the specification of them is also shown.

[0014]

In the first column, a lens face shown with * mark represents an aspheric surface. The shape of the aspheric surface is represented by:

$$S(y) = \frac{y^2/r}{1+\sqrt{1-\kappa y^2/r^2}} + \sum_{i=2}^{5} C_{2i} y^{2i}$$

where

y: Height in a direction vertical to an optical axis

S(y): Displacement in an optical axis direction at height y

r: Radius of curvature on an optical axis

κ: Conic coefficient

Cn: n-th aspheric surface coefficient

In [Aspheric surface data], conic coefficient κ and aspheric surface coefficient C_n are shown. Lens face Nos. of those in the groups from the first lens group G_1 to the fourth lens group G_4 are represented by consecutive numbers started from 1 while lens face Nos. of those in the fifth lens group G_5 are represented by consecutive numbers started from 60.

[0015]

Table 2 shows the specification of the detachable lens group G_6 when the first interchangeable lens group G_{A1} is used. Table 3 shows the specification of the detachable lens group G_6 when the second interchangeable lens group G_{A2} is used. Lens face Nos. of those in detachable lens group G_6 are represented by consecutive numbers started from 40 with regards to the interchangeable lens groups G_{A1} and G_{A2} and by consecutive numbers started from 50 with regards the uninterchangeable lens group G_B.

[0016]

In this embodiment, the interchangeable lens groups G_{A1} and G_{A2} in

the detachable lens group G_6 are exchanged and then the uninterchangeable lens group G_B is moved in the optical axis direction. This provides the switching of the conversion magnifications of $\beta=0.818(Y=4.5)$ and $\beta=0.545(Y=3.0)$. Furthermore, three types of imaging sizes can be handled including the case where the detachable lens group G_6 is removed ($Y=5.5$). The uninterchangeable lens group G_B in the detachable lens group G_6 is at a position closest to the image when the conversion magnification β is minimum ($\beta=0.545$).

[0017]

[Table 1]

[Entire specification]

f =8.27~152 Y=5.5mm

[Lens specification]

No	r	d	ν	n_d
1	-319.712	1.90	25.40	1.80518
2	178.860	2.35		
*3	145.496	0.11	56.30	1.49521
4	145.496	12.50	95.00	1.43875
5	-168.884	6.96		
6	100.108	11.10	67.87	1.59318
7	-295.247	0.09		
8	57.607	8.30	67.87	1.59318
9	173.592	(d_9)		
10	73.633	0.81	35.72	1.90265
11	12.090	5.70		
12	-53.921	4.80	23.01	1.86074
13	-13.650	1.00	46.54	1.80410
14	68.093	0.10		
15	20.390	5.00	30.83	1.61750
16	-29.999	0.81	39.82	1.86994
17	65.661	(d_{17})		
18	-27.543	0.81	43.35	1.84042
19	51.000	3.20	23.01	1.86074
20	-138.389	(d_{20})		
21		4.40		
22	-105.322	4.70	64.10	1.51680
23	-30.168	0.10		
24	54.182	5.20	69.98	1.51860
25	-115.102	0.10		
26	50.239	6.70	65.77	1.46450
27	-54.000	2.00	39.82	1.86994
28	561.006	38.24		
···Position at which detachable lens group is attac				
60	41.484	6.10	65.77	1.46450
61	-45.254	0.70		
62	-55.060	1.50	39.82	1.86994
63	27.737	7.00	64.10	1.51680
64	-57.220	0.10		
65	78.227	6.10	40.76	1.58144
66	-27.232	1.50	39.82	1.86994
67	-4389.239	0.10		
68	35.109	5.50	65.77	1.46450
69	-68.189	10.00		
[Aspheric surface data]				
70	∞	30.00	38.03	1.60342

71	∞	16.20	64.10	1.51680
72	∞	1.29		

[Aspheric surface data]

No=3 κ=-2.9093 C_4 =-1.66430×10^{-7}
C_6 = 2.15870×10^{-11}
C_8 =-2.79640×10^{-14}
C_{10}= 7.43600×10^{-18}

[Variable distance]

f	8.27	152.00
d_9	0.57	47.75
d_{17}	52.05	4.97
d_{28}	1.38	1.27

[0018]

[Table 2]

f =6.77~124.3 Y=4.5mm β=0.818

No	r	d	ν	n_d
28	561.006	7.14		
40	-79.916	1.00	52.30	1.74809
41	46.350	2.30	23.01	1.86074
42	73.707	5.80		
43	-40.956	3.00	64.10	1.51680
44	-29.475	1.60		
50	45.254	3.90	82.52	1.49782
51	1988.384	13.50		

[Table 3]

f =4.51~82.9 Y=3.0mm β=0.545

No	r	d	ν	n_d
28	561.006	3.14		
40	-36.645	1.00	52.30	1.74809
41	27.234	2.30	23.01	1.86074
42	73.183	20.80		
43	-40.356	1.50	25.50	1.80458
44	-44.055	2.90	67.87	1.59318
45	-28.757	0.20		

[0020]

Figure 4 shows the spherical, astigmatic, and distortion aberration at the wide angle end and the telescopic end when the detachable lens group G_6 of this embodiment is removed. Figure 5 and Figure 6 show the aberration diagrams when the detachable lens group G_6 is attached and the

first interchangeable lens group G_{A1} and the second interchangeable lens group G_{A2} are used, respectively. As can be seen from the shown aberrations, each of the embodiments shows a favorable imaging performance in each of the various imaging sizes.

[0021]

[Effects of the Invention]

As described above, according to the present invention, an imaging size conversion optical system is realized that prevents the change of the field angle even when a camera having a different imaging device size is attached with a photography lens, and furthermore that is small, light-weight, high-performance, and bright.

[Brief Description of the Drawings]

[Figure 1]

A diagram illustrating the configuration of the lens of one embodiment of the present invention.

[Figure 2]

A diagram illustrating the configuration of the main part when the detachable lens group is attached and the first interchangeable lens is used.

[Figure 3]

A diagram illustrating the configuration of the main part when the detachable lens group is attached and the second interchangeable lens is used.

[Figure 4]

A diagram illustrating aberrations when the detachable lens group is removed.

[Figure 5]

A diagram illustrating aberrations when the detachable lens group is attached and the first interchangeable lens is used.

[Figure 6]

A diagram illustrating aberrations when the detachable lens group is attached and the second interchangeable lens is used.

[Explanation of Reference Symbols]

G_1	First lens group
G_2	Second lens group
G_3	Third lens group
G_4	Fourth lens group
G_5	Fifth lens group
G_6	Detachable lens group
G_{A1} and G_{A2}	Interchangeable lens group in the detachable lens group
G_B	Uninterchangeable lens group in the detachable lens group

FIGURE 1
WIDE ANGLE END
TELESCOPIC END

FIGURE 4
WIDE ANGLE END
SPHERICAL ABERRATION
ASTIGMATIC ABERRATION
DISTORTION ABERRATION
TELESCOPIC END
SPHERICAL ABERRATION
ASTIGMATIC ABERRATION
DISTORTION ABERRATION

FIGURE 5
WIDE ANGLE END
SPHERICAL ABERRATION
ASTIGMATIC ABERRATION
DISTORTION ABERRATION
TELESCOPIC END
SPHERICAL ABERRATION
ASTIGMATIC ABERRATION
DISTORTION ABERRATION

FIGURE 6
WIDE ANGLE END
SPHERICAL ABERRATION
ASTIGMATIC ABERRATION
DISTORTION ABERRATION
TELESCOPIC END
SPHERICAL ABERRATION

ASTIGMATIC ABERRATION
DISTORTION ABERRATION

FIG. 2

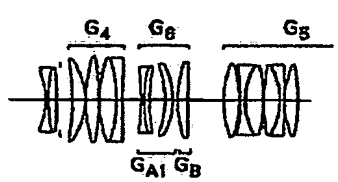


FIG. 3

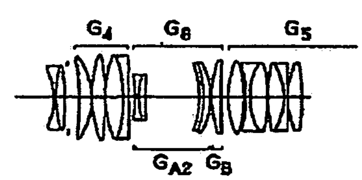


FIG. 1

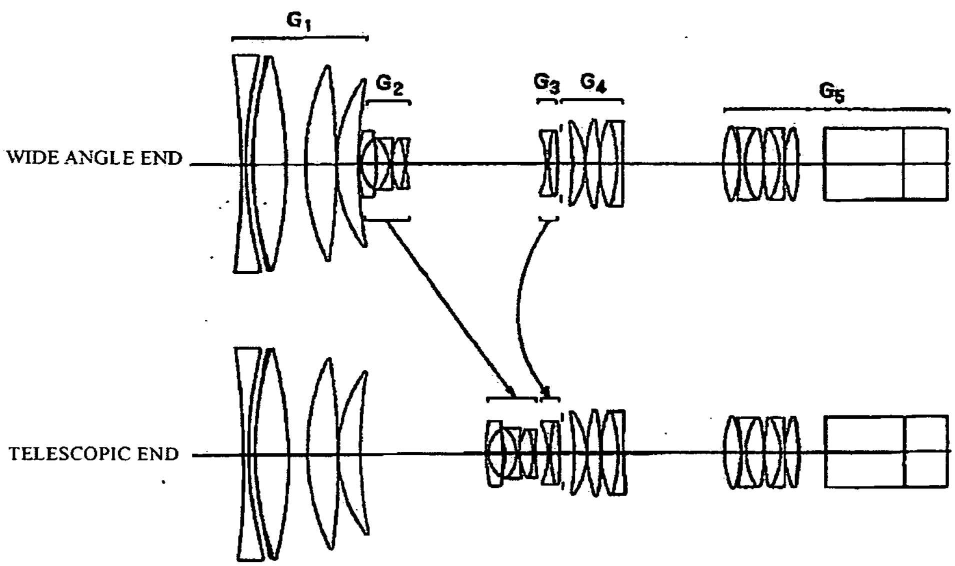


FIG. 4

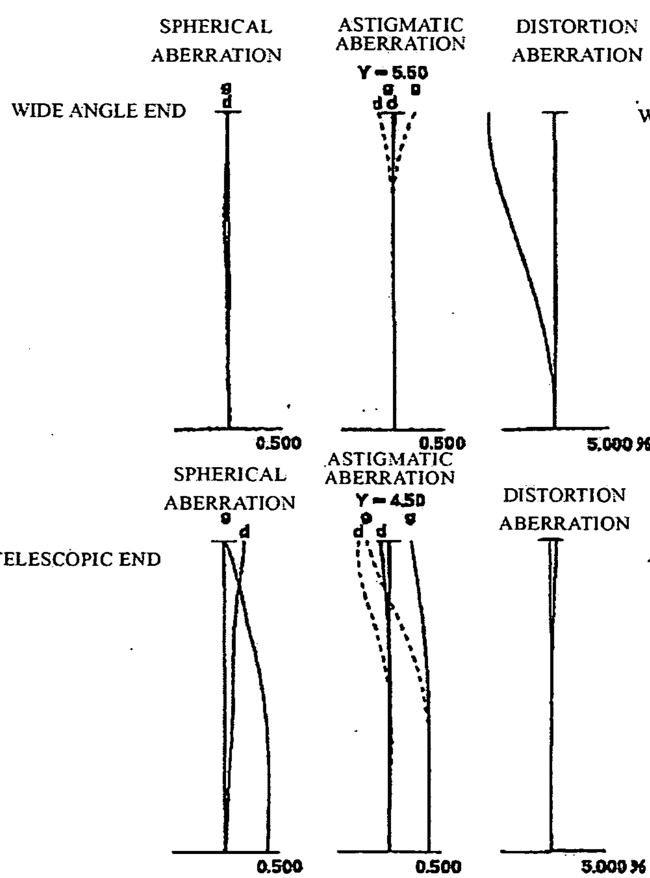


FIG. 5

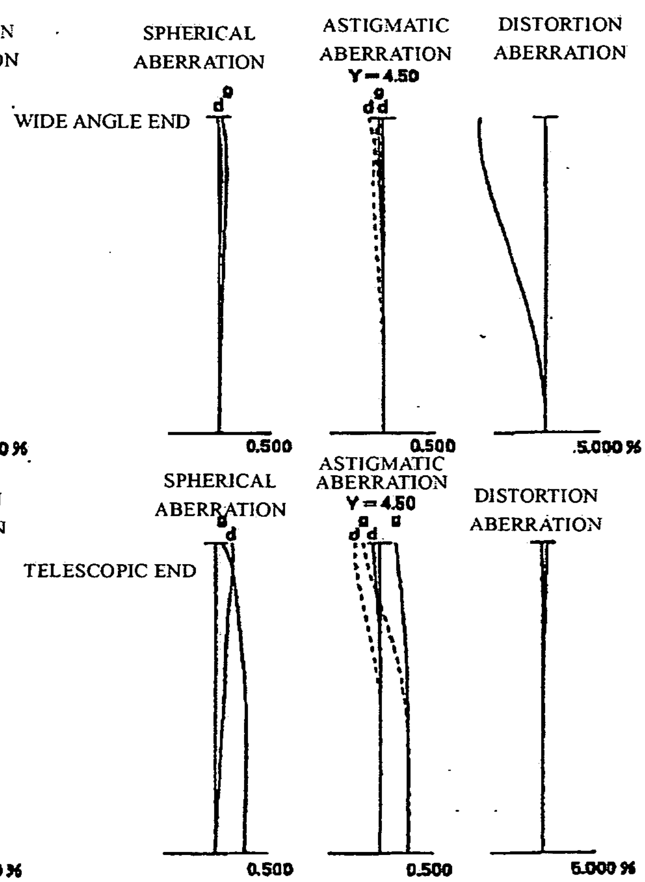
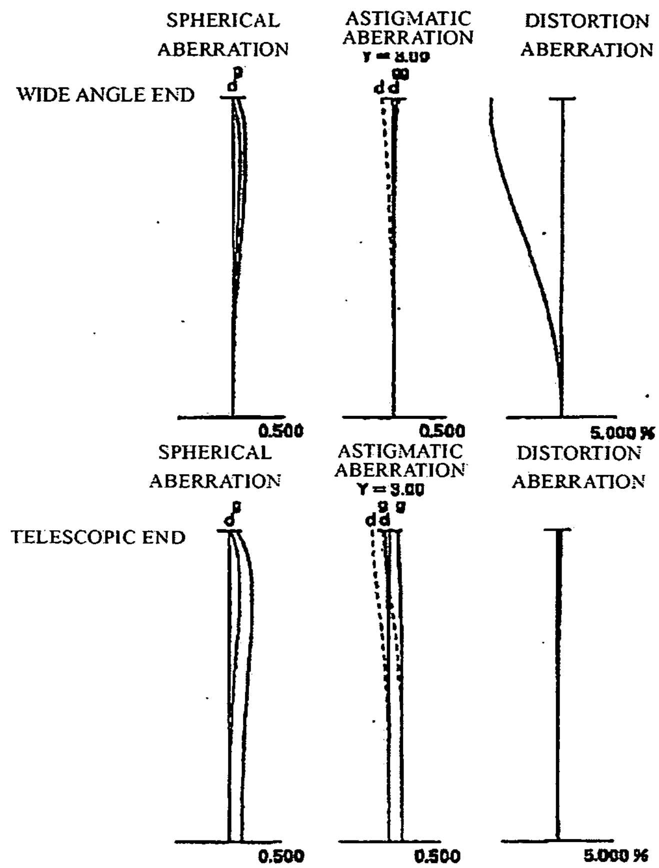


FIG. 6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